Saskatchewan

A D F

Agriculture Development Fund

FINAL REPORT

DEVELOPMENT OF A FARM SCALE HERB AND SPICE WASHER/DRYER

19980267

Funded by
The Agriculture Development Fund

March 2001

Prepared by: Northern Lights Herb Corp.

SAF
Adding value to agriculture through research and development

Project No. 7199E
Date: January 2001
Tested at Humboldt

ADF#98000267

Final Report

Development of a Farm Scale Herb and Spice Washer/Dryer

Alan Boyden, A.Sc.T.
Assistant Manager
Energy and Processing

Darrell Lischynski, P.Eng.
Manager
Energy and Processing

Philip Leduc, P.Eng.
Senior Manager
Research and Development

James Wassermann, P.Eng.
Vice President
Saskatchewan Operations

Acknowledgement

PAMI wishes to acknowledge the funding support provided by the Agriculture Development Fund of the Saskatchewan Department of Agriculture and Food.

Table of Contents

Page

1. Summary 1

2. Technical Report 2
   - 2.1 Introduction 2
   - 2.2 Objectives 2
   - 2.3 Project Scope 2
   - 2.4 Results and Discussion 3

3. Project Developed Materials 17

4 Acknowledgements 18

1. Summary

Northern Lights Herb Corp. (NLHC) is a group of Herb and Spice growers near Prince Albert, Saskatchewan. NLHC approached the Prairie Agricultural Machinery Institute (PAMI) to assist in the design and construction of a machine suitable to dry the various herb and spice crops that are grown by their members. The unit was designed by NLHC and PAMI, built at PAMI in Humboldt, Saskatchewan and preliminary testing was done during the 1999 and 2000 crop years.

This project was done in several stages. Initially, PAMI met with NLHC to determine the members' needs and explore the basic configuration and operation of the unit. Some research was done on other available equipment and drying characteristics of herb and spice crops. A final configuration was then developed. Detailed design was done and from this a set of detailed drawings was developed. The unit was then fabricated at PAMI and then initial tests done in cooperation with NLHC members. Some small modifications have been done to the unit to fine tune its operation.

2. Technical Report

2.1 Introduction

Northern Lights Herb Corp. (NLHC) is a group of Herb and Spice growers near Prince Albert, Saskatchewan. NLHC approached the Prairie Agricultural Machinery Institute (PAMI) to assist in the design and construction of a machine suitable to wash and dry the various herb and spice crops that are grown by their members. The unit was designed by NLHC and PAMI, built at PAMI in Humboldt, Saskatchewan and preliminary testing was done during the 1999 and 2000 crop years with final revisions in the winter of 2000/2001.

2.2 Objectives

The objectives of this project were to:

1) Design a machine to accommodate the herb and spice washing and drying needs of the NLHC members.
2) Construct the machine designed in the previous step.
3) Perform preliminary tests to assess the machine's suitability and performance.

2.3 Project Scope

This project was done in several stages. Initially, PAMI met with NLHC to determine the members' needs and to explore the basic configuration and operation of the unit. Some research was done on other available equipment and drying characteristics of herb and spice crops. Research was carried out to find out the need for foliage washing and equipment available for it. A final machinery configuration was then developed. Detailed design was done and from this a set of detailed drawings was developed. The unit was then fabricated at PAMI and then initial tests done in cooperation with NLHC members. Some small modifications will be done to the unit to fine tune its operation.

2.4 Results and Discussion

2.4.1 Design

Needs Assessment: Meetings were held between NLHC and PAMI to assess the needs of the NLHC members. Crop drying previously was done by manually collecting the crop material, placing it in a grain drying bin and moving air through it. This was very labour intensive and did not produce a very consistent end product. Because of the amount of manual labour involved, this process did not encourage growers to expand their operation. Therefore, a primary concern for this new unit would be to reduce the amount of manual handling of the material.

Although the original concept for this machine was to incorporate washing and drying in the same machine, it was decided to focus on drying. This was done for two reasons. The first reason being that it had just been determined that washing foliage might result in the active ingredients being washed away. Washing root crops typically was done using a soaking/agitating process, which did not lend itself well to incorporation with a drying machine. It was found that these types of washing machines are available. Based on the above information, it was decided to design a machine to primarily be a dryer but that could possibly be adapted to washing crop material if necessary. The dryer bins were designed so that foliage can be placed in them and washed prior to drying. While this increased the dryer cost slightly, it would not limit the function of the machine as a dryer.

It was thought that the configuration of the dryer should be a set of bins that could be loaded either by hand or by using a cutter conveyor system to be developed in the future. These bins would be loaded in the field and taken to the dryer using a front-end loader (FEL). The bins should be small enough that they could be filled by hand but large enough to reduce the physical labour as much as possible. The dryer itself would be a trailer that could be placed in the field for loading and then transported to an electrical power source for drying. Because most farms have a welder plug (50A at 220 V), the maximum electrical demand could not practically exceed this. It was decided to make the dryer as portable and self contained as possible by mounting propane tanks on the unit. To aid in portability and versatility, the dryer would also have to have legal dimensions and weight for road travel and be capable of being towed by a truck typical of those owned by NLHC members. Because the products were to be used as food, the interior of the bins would need a food grade coating, and the heater could not be a direct-fired unit. The bins would need at least two levels of shelving with provisions for more levels in the future.

The above needs were all considered when proceeding with subsequent dryer design.

Drying Criteria: NLHC members offered as much information as they had on drying characteristics of the crops they grow. However, there is not much known about the

drying criteria for crops such as comfrey and feverfew. Some information was found regarding drying of ginseng roots. This indicated that airflow should be about 40 cfm/ft^2 of floor area and the static pressure should be about 1.5 in. wg. The plenum size should allow about 1,000 cfm/ft^2 and maximum air temperature should be 100°F. Some information was also found on the drying of herb crops. This indicated that maximum air velocity should be 10 to 20 ft/min and maximum air temperature should be 120°F. No other information on herb crop drying was found. However, the information collected was very useful in deigning the fan, air distribution, and heating components of the dryer.

Dryer Configuration: Based on the above information, a basic dryer configuration was established. The dryer was built upon a triple axle flatbed trailer, and the main air plenum was built on top of the trailer bed. The fan and heater were mounted on the hitch and blew the air into the plenum from the front. Two propane tanks were also mounted on the hitch. Twelve bins were used to hold the crop material, and they would stack one or two high on the plenum in a two wide by three long configuration (**Figure 1**). The bins had two levels of screen, and one wall was hinged at the top to allow the material to be dumped out the side when dry. Removable roofs were also included. Stake pockets were included on the bins for moving the bins using a FEL (**Figure 2**). Provisions were made for holding the bins and roofs on the dryer during road travel.

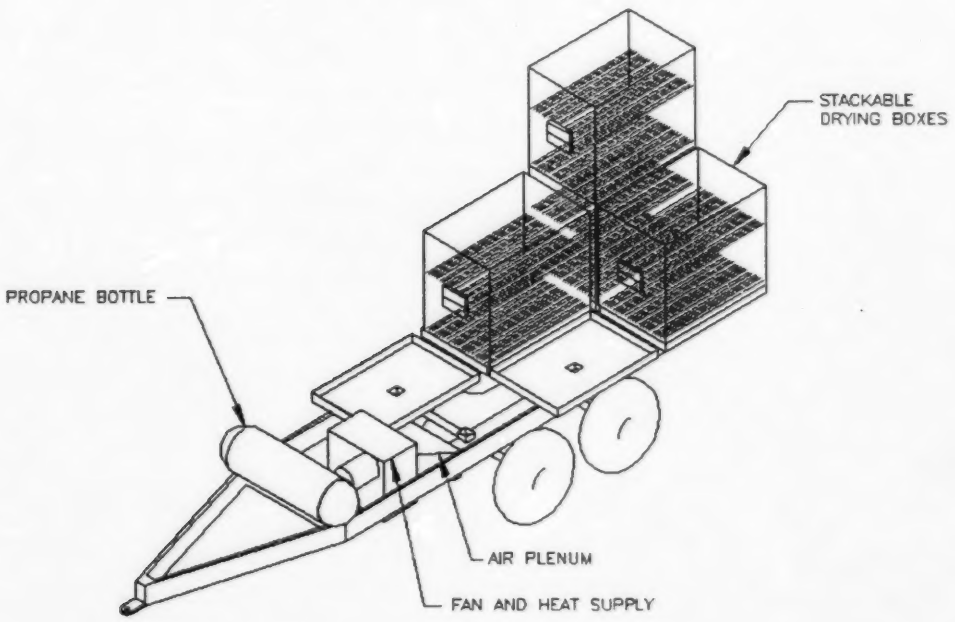

Figure 1. Dryer Configuration.

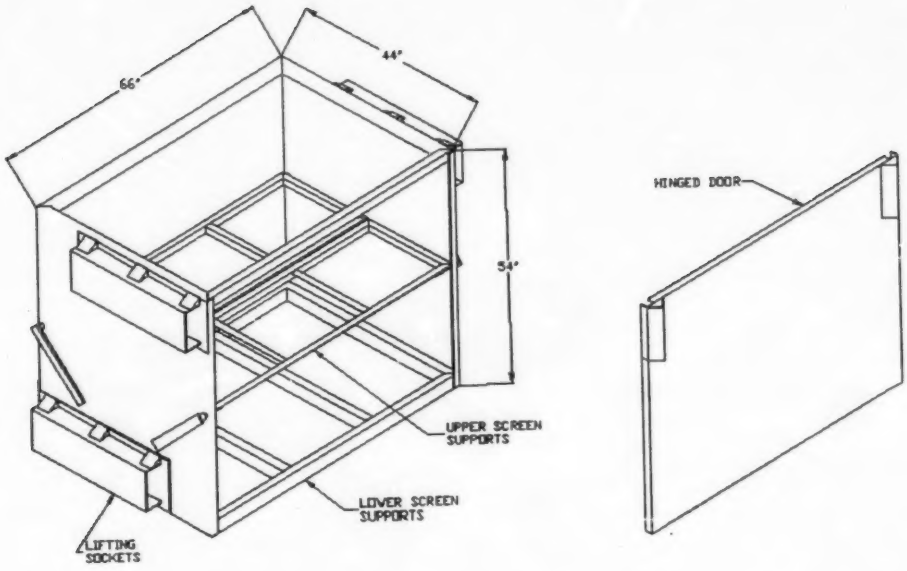

Figure 2. Bin Configuration.

2.4.2 Dryer Construction

Plenum: The plenum for the dryer was built from sheet metal and attached to the bed of the trailer. The top of the plenum was divided into six sections (2 wide x 3 long) to receive six bins. Tapered supports were built into the plenum to match the bottoms of the bins to allow for easily lining up the bins on the dryer. The tops of the bins had these same tapered supports so any bin could be placed on the dryer or stacked on top of any other bin (**Figure 3**).

Figure 3. Dryer Plenum.

The supports that were placed laterally between the pairs of bin mounts had holes cut in them to partially restrict the airflow as it travelled along the length of the dryer. This was done to aid in balancing the air distribution between bins. Holes were cut in the top of each bin receiver section of the plenum. Adjustable covers were installed over each of these holes to allow for further fine tuning of the air distribution between each bin and within each bin (**Figure 4**).

Figure 4. Air Distribution Covers.

Bins: Twelve identical bins were built from sheet metal. Each bin was about 6 ft wide by 4 ft deep by 5 ft high. An expanded metal screen was attached to the bottom of each bin, and another two-part hinged screen was mounted half way up the bin (**Figure 5**). One of the long walls of each bin was hinged at the top for emptying the bin after drying (**Figure 6**). Two sets of stake pockets were mounted on each bin. One set was meant for moving the bin on and off of the dryer using a FEL, and the other set was meant to hold the bin on a harvesting machine to be developed in the future. Inspection ports were installed at each screen level (**Figure 7**). The exterior of the bins received a coat of high-grade enamel paint, and the insides received a coat of food grade epoxy paint. Six roofs were also built from aluminium. These could easily be lifted to the top of the bins when installed on the dryer (**Figure 8**). Chains and other tie-downs were included to hold the bins and roofs on the dryer during transport.

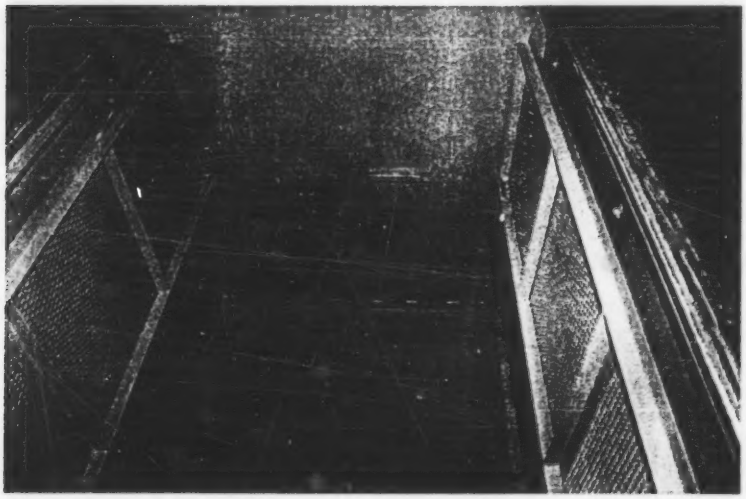

Figure 5. Bin Screens.

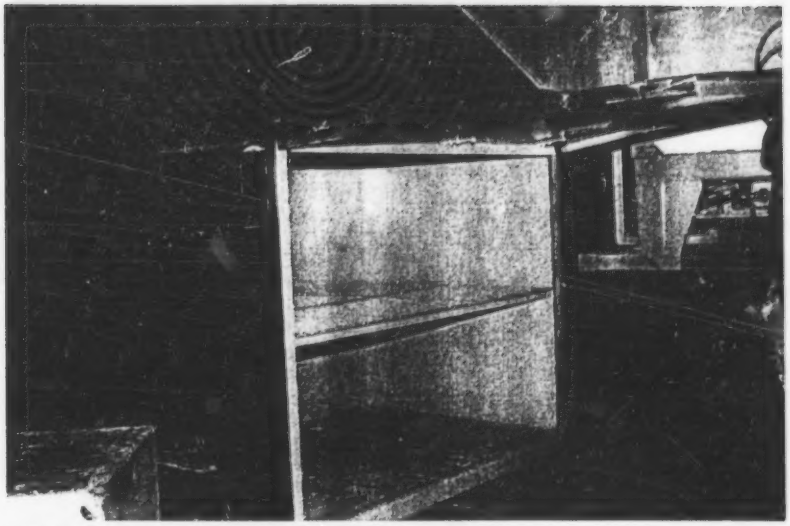

Figure 6. Hinged Wall For Emptying.

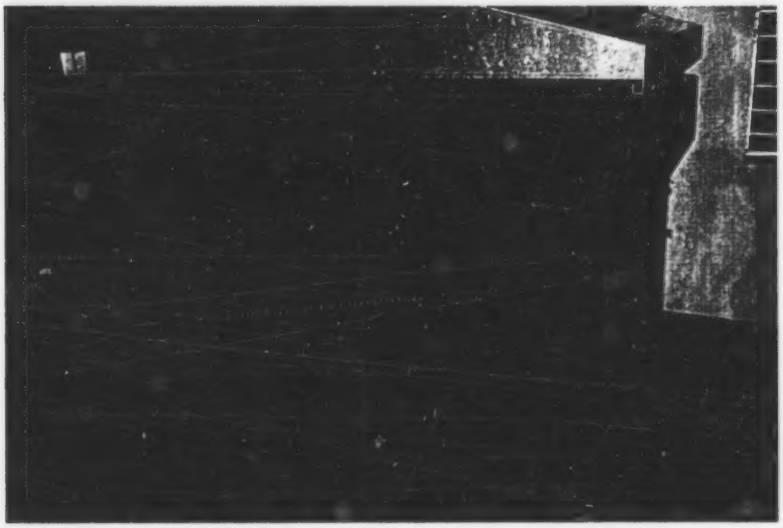

Figure 7. Inspection Ports.

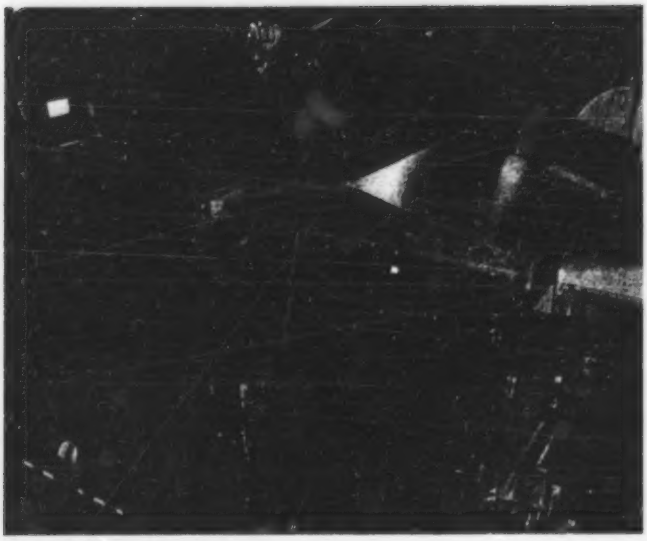

Figure 8. Bin Roofs.

Air Handling and Heating: Based on the information gathered on herb drying, it was determined that at least 2,550 cfm of airflow was required. To achieve a maximum temperature of 120°F with an ambient temperature of 60°F, a burner capable of 168,000 btu/hr would be required. The fan chosen for the dryer was a Flaman 5 hp inline centrifugal fan. This fan could easily provide the required airflow, was readily available, and could be operated from a standard farm welder plug. The burner chosen was an Industrial Commercial Equipment Model TPB-160 QGR. This unit had a rating of 160,000 btu/hr, had a thermostatically controlled modulating valve, and incorporated a heat exchanger to ensure that no combustion products came in contact with the crop being dried. The fan and burner were interlocked to ensure that the burner would not operate until the fan was running.

Two, 74.3 gallon propane tanks were mounted on the hitch of the dryer. At maximum heat input, these tanks could fuel the burner for 62 hours. These tanks were automotive propane tanks and could easily be filled by a propane delivery truck or at any retail gas station that had facilities to fill propane powered vehicles (**Figure 9**). These have now been removed as hitch weight was excessive and co-operators preferred to use a larger bulk propane tank system, as suppliers did not wish to provide propane service to the smaller tanks.

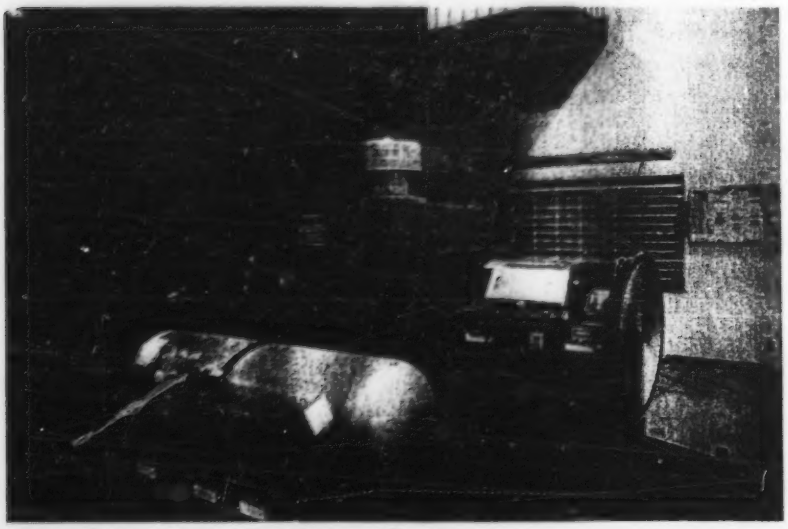

Figure 9. Fan, Heater and Propane Tanks.

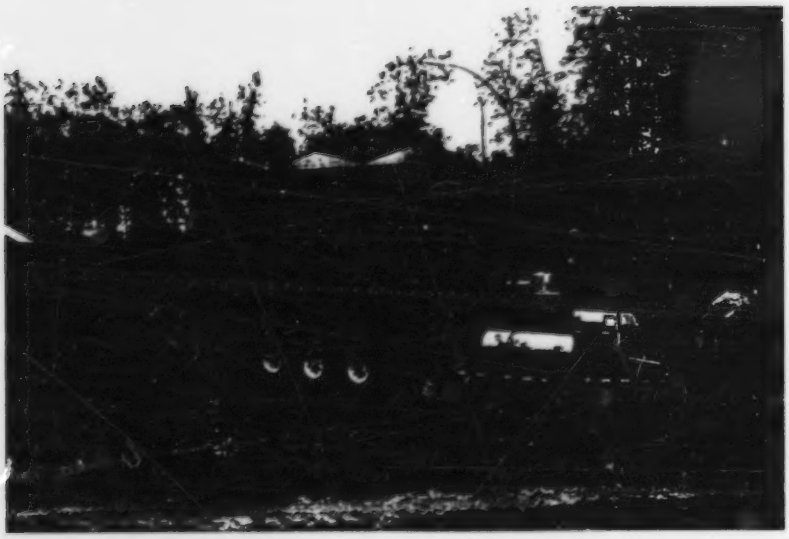

Figure 10. Complete Dryer.

2.4.3 Dryer Operation

Before the dryer was used to dry crop material, some initial testing was done. The operation of the fan and burner was checked. Airflow was also checked, and all dampers were initially adjusted to give equal airflow to all bins with no bins installed.

The first crop material dried was feverfew. Six bins were loaded using pitchforks and by hand (**Figure 11**). Initial moisture content of the feverfew was 82.5%. The material was dried for four days, using the heater for the entire drying time. Total drying time was very acceptable, but it was noted that soon after drying began, the crop material shrank enough that it pulled away from the edge of the bins. This resulted in increased airflow channelling up the sides of the bins and reduced airflow in the centre of the bins. Some crop molding was noted to occur in the centre of the bins.

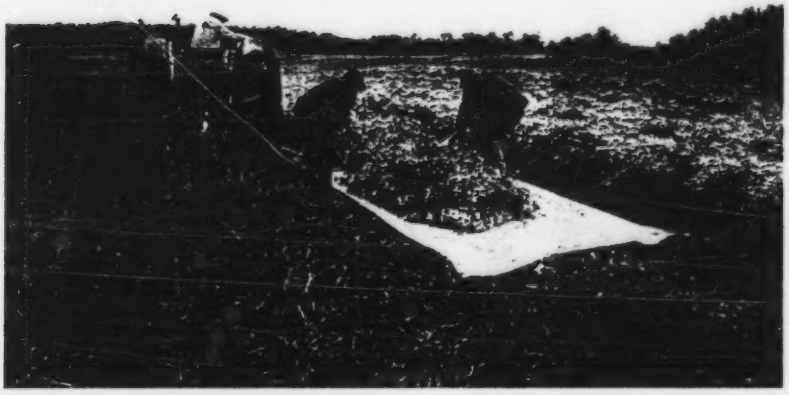

Figure 11. Cutting Feverfew.

Another observation after drying was complete was that the crop appeared to re-hydrate after taken out of the dryer. An end user of the feverfew noted this, as it was delivered in a state that appeared to be dry, but it appeared to get wetter after it was received. This is probably due to a phenomenon known as moisture rebound. This occurs when materials are dried quick enough that the outer part of the material is dried and appears dry to touch, but there is still a significant amount of moisture at the inner part of the material. After a period of time, this moisture equalizes within the material, and therefore the outer part appears to get wetter even though the total moisture within the material hasn't changed. To reduce the effect of this, operators have to ensure that the crop material is dried completely through before it is removed from the dryer. This could be done by breaking a piece of the material and visually noting if it is still wet inside, or by determining the moisture content using an oven dry procedure.

The dryer was next used to dry comfrey. Care was taken to load the bins so there was more crop material near the edges and less at the centre. This greatly improved the overall drying uniformity and no molding was noted.

The dryer operator had used the heater for the entire drying process. This reduced drying time compared to drying with ambient air, and also ensured that drying would continue throughout high humidity time periods and at night when ambient temperature was lower.

The dryer was used to dry 20 bins of St. John's Wort and 20 more bins of feverfew. Drying time to a final moisture content of about 10% was 3 ½ days.

During the 2000 crop year, 42 bins of fireweed were put through the dryer. Based on previous experience, the following procedure was used. All bins were loaded by hand, but the front bins were loaded with more product than the rear bins. This was because previous experience had noted that the front bins were drying faster then the rear bins, probably due to higher airflow. All twelve bins were placed on the dryer and the fan and heater started. After two days, the material was fluffed up by hand through the inspection ports to ensure that it was not getting so packed that air channelling would occur. After three days of drying, the bottom bins were at or near dry, and they were then exchanged with the top bins. Drying then continued for another three days and the burner was then shut off for a day of cooling. The resulting crop product was dried evenly and crop quality was very good. Average wet crop weight going into the dryer was 425 lb/bin and average dry weight/bin was 131 lb/bin.

It was noted during this process that it was important to have the dryer level. If it was not level, moving the bins on and off using a FEL was very awkward. If the dryer was level, the bins nested well on the plenum and on each other (**Figure 12**).

Figure 12. Bin Loading.

After drying was complete, the crop material was very matted together (**Figure 13**). This was an advantage if the entire bin load was to be moved as a unit into a bag or storage bin. However, if the material needed to be separated, a pitch fork was needed. Care had to be taken to not break the material much, as it is quite fragile after drying. One improvement needed in the future is a mechanism for holding the hinged wall open during unloading, as it is quite heavy and awkward.

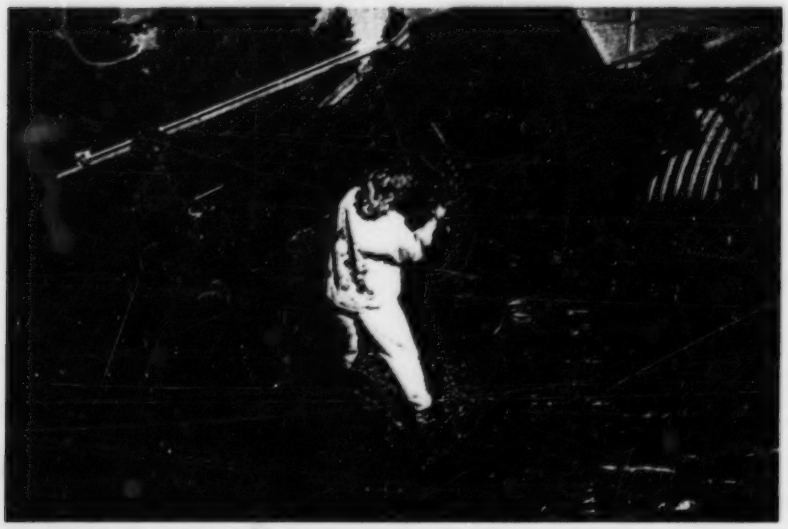

Figure 13. Bin Unloading.

The dryer was used for drying about 1,500 lb of Echinacea roots. This amount of roots filled eight bins on both levels. After digging, the roots were soaked and then washed twice in a tumble washer. They were then placed in the dryer and dried with the heater on for 6-8 days. The resulting dry roots weighted 375 lb. Root final quality was noted to be very good. However, because of the screen size, some of the smaller roots passed through the screen and broke off.

During the 2000 crop year, an additional six bins of Echinacea and nine bins of St. John's Wort were dried with similar results as noted above.

2.4.4 Dryer Modifications

In general, the operators were very pleased with the operation of the dryer. However, because it is a first of its kind, some modifications are needed to improve its functionality. PAMI will be doing these modifications using PAMI funds in the near future, as all project funding has been expended.

At first glance, the unloading of the bin shown In Figure 13 may be a safety concern. However, the bin is held on to the FEL with a hook mechanism, and PAMI will be adding a mechanism to hold the doors open in the future.

It was originally intended to make the dryer as self-contained as possible, so the two propane tanks were included in the design. However, it was soon found that they were too small to last for more than a day or two, and propane companies are reluctant to deliver small quantities often. Because of this, most of the dryer operation was done using a separate 1,000 gallon propane tank. PAMI will be removing the two tanks mounted on the dryer. This will also reduce the hitch weight, which will be an added improvement.

As previously mentioned, a mechanism will be added to keep the hinged wall open during bin emptying. Positive locks to hold the doors closed during drying operation will also be added as the present rubber tarp straps allow the wall to open slightly if too much material is packed into the bins.

The hitch jack will be repaired, as it has been bent slightly. Adding additional shelves will also be considered, and the air leaks in the plenum will be sealed.

3. Project Developed Materials

The herb dryer has been built and, as mentioned in the proposal, is now owned by Northern Lights Herb Corporation.

PAMI is presenting the results of this project at the 2001 Herb and Spice Conference in Saskatoon.

Drawings for the dryer are available from PAMI at no charge to other Saskatchewan herb and spice producers.

4. Acknowledgements

Decals acknowledging ADF's contribution to the project are installed on the dryer, ADF has also been acknowledged in the presentation given at the herb and Spice Conference.